

REMARKS

Applicants respectfully request reconsideration of the application, as amended, in view of the following remarks.

The rejection of Claims 1, 7, 19, 22, 26, 29, 37 and 38 under 35 U.S.C. § 102(b) as anticipated by JP 1997-272901 (JP '901) and the rejection of Claim 20 under 35 U.S.C. § 103(a) over JP '901 are respectfully traversed.

The present invention as set forth in **Claim 1** provides a process for compacting a green compact, comprising:

spraying a powdery higher fatty acid-based lubricant which is dispersed in a dispersion comprising a surfactant onto an inner surface of a die, which is heated;

filling a raw material powder whose major component is an active metallic element into the die;

compacting the raw material powder by warm pressurizing to make a green compact; and

ejecting the green compact from the die;

whereby the resulting green compact has a high density;

wherein the active metallic element is titanium or aluminum;

wherein, in the compacting step, a new metallic soap film being different from the higher fatty acid-based lubricant and comprising the active metallic element is formed on a surface of the green compact.

Based on the present invention, a high-pressure forming of Ti powder and Al powder can be carried out on an industrial scale, departing from the conventional technical knowledge.

The Examiner has recognized that JP '901 does not disclose that "in the compacting step, a new metallic soap film different from the higher fatty acid-based lubricant and

comprising the active metallic element is formed on a surface of the green compact". Thus, the present invention cannot be anticipated. The Examiner has however taken the position that the formation of the new metallic soap also inherently occurs in the process of JP '901. Applicants disagree as explained below.

In addition, JP '901 does not disclose or suggest the use of a surfactant together with the higher fatty acid based lubricant. The Examiner has taken the position that the zinc stearate disclosed in [0016] of JP'901 qualifies as both lubricant and anionic surfactant. However, in the present invention, the surfactant is different from the lubricant. See for example page 23, [0075] to page 25, [0080]. Thus, the present invention cannot be anticipated.

Contrary to the Examiner's position that the formation of the new metallic soap also inherently occurs in the process of JP '901, a metal soap film as disclosed in the present invention cannot be formed because of the following reasons.

The specification of the present invention discloses at paragraph [0004] as follows:

[0004] In order to utilize the characteristics of green compacts, green compacts are required to have a high density in most cases. In order to produce high-density green compacts, it is inevitable to form raw material powders by pressuring by high pressures. Usually, however, the higher the compacting pressure is, the larger the frictional force between the raw material powders and dies is. As a result, when raw materials are formed by pressuring by large pressures, it has become difficult to eject the resulting green compacts from the dies. Moreover, **galling and the like occur to damage the dies when ejecting the green compacts, or the surface of the green compacts is roughened.**

Paragraph [0011] discloses that:

[0011] However, it has been the technical common knowledge that it is impossible to form raw material powders comprising an active metallic element such as Ti and Al by high pressures at industrial level. This is because galling occurs on the inner surface of dies instantaneously or the inner surface of dies is roughened when such high-pressure compacting is carried out. Moreover, it is because the resulting green compacts cannot be ejected from dies. In addition, very expensive dies cannot be used even after one and only high-pressure compacting operation so that a great loss might arise.

If galling or the like occurs, even though partly, between a formed body and an inner surface of a die, an excellent formed body is not obtained. As a result, the die is damaged, and the duration of life of the die is shortened. Furthermore, decrease of ejection force doesn't occur.

The specification discloses at paragraph [0026]:

[0026] In accordance with the **present compacting process**, even when active metallic powders are used, it is possible to produce high-density green compacts by high-pressure compacting. In this instance, no galling and the like occur on the inner surface of dies substantially, and accordingly it is possible to produce green compacts with favorable dimensional stability and superficial roughness. Therefore, the longevity of dies is extended, the yield of raw material powders is improved, and the working cost is reduced by near net shaping. Thus, it is possible to sharply reduce the cost of green compacts as well as sintered bodies made therefrom.

In order to exhibit the effect of the present invention, it is necessary to form a uniform metal soap film on the surface of the formed body which is opposite to the inner surface of the die.

Here, what becomes important is a die lubrication which is carried out before a pressing and forming process (a compacting process), namely, the spraying step of the present invention.

JP '901 discloses that zinc stearate and the like are dispersed into a solvent to be sprayed to an inner surface of a die. In this conventional metal lubricating method, lubricants such as zinc stearate and the like are merely adhered to the inner surface of the die directly. The same applies to the case in which lubricants are merely dispersed into a solvent such as water or the like to be sprayed. This is because the solvent such as water or the like is merely used for improving the convenience of spraying, and it is rapidly vaporized on the inner surface of the die. As a result, the lubricants to be sprayed remain on the inner surface of the die in the condition that they are hardly changed.

Such condition means that particulate lubricants are merely adhered to the inner surface of the die due to adhesive force of the lubricants themselves. Furthermore, when particulate lubricants are merely dispersed into water or the like, the lubricants and water becomes the condition that they are easily separated from each other, and it is difficult to carry out a uniform coating on the inner surface of the die.

In this manner, if metal powder is filled in an inner surface of a die to which lubricants are merely adhered, the lubricants are easily peeled off from the inner surface of the die one after another by contacting with the metal powder because adhesive force between lubricants and the inner surface of the die is weak. Then, the portion where the metal powder is directly brought into contact with the inner surface of the die increases, and galling or the like occurs between an outer surface of a formed body and the inner surface of the die. As a result, an excellent high-pressure formed body is not obtained, and decrease of ejection force doesn't occur.

Further, if zinc stearate is used as lubricant, it is dissolved at the temperature of 150°C, and **a uniform lubricant film is not formed.**

On the contrary, in the present invention, a higher fatty acid-based lubricant is once dispersed into water containing surfactants, and then, such dispersion liquid is applied to an inner surface of a die uniformly, thereby carrying out metal lubrication.

Due to existence of surfactants, metallic salt of the higher fatty acid such as lithium stearate which is hardly dissolved into water is dispersed into dispersion liquid uniformly and finely. When such dispersion liquid is applied to the inner surface of the die, metallic salt of the higher fatty acid is adhered to the inner surface of the die uniformly and closely (without space). Furthermore, by adjusting the density of metallic salt, it is possible to form a thin and uniform lubricating film on the inner surface of the die easily.

Moreover, the surfactants make viscosity of the dispersion liquid higher, so they exhibit the effect that metallic salt of the higher fatty acid is strongly adhered to the inner surface of the die. At this time, the dispersion liquid is applied to the inner surface of the heated die to be a so-called baking finish condition, and a strong lubricant film is formed on the inner surface of the die. Even if the lubricant film is brought into contact with metal powder which is filled in the die, peeling, defects and the like don't occur easily. As a result, a pressing and forming process (a compacting process) is carried out under the condition that the lubricant film comprising metallic salt of higher fatty acid is uniformly formed between the metal powder and the inner surface of the die. Then, a metal soap film is stably formed on the whole surface of a formed body which is opposite to the inner surface of the die, and an excellent high-pressure formed body is obtained. In addition, it is possible to eject the formed body from the die with low ejection force even if the formed body comprises Ti or Al.

JP '901 describes that metallic salt of higher fatty acid is dispersed into water, but JP '901 does not disclose or suggest the use of surfactants, which is disclosed in the present invention.

In the present invention, the surfactants have a role in forming the lubricating film comprising metallic salt of higher fatty acid on the inner surface of the die stably. Namely, when the dispersion liquid is applied to the inner surface of the heated die, moisture and the like are rapidly vaporized, but the surfactants themselves remain without being vaporized. The remained surfactants work as a filler for fixing the metallic salt of higher fatty acid to the inner surface of the die. Such effects of surfactants are not obvious to a person of ordinary skill in the art based on JP '901.

Even if a metal soap is generated in JP '901, the level of this is quite different from that of a metal soap film which is disclosed in the present invention.

In JP '901, even if there is the possibility that a metal soap is generated, **it is merely a very small portion between the surface of the formed body and the die, BUT NOT A FILM as claimed.** In other words, such metal soap would not be the same level as that of the metal soap film of the present invention, in which ejection force decreases and an excellent high-pressure formed body can be mass-produced industrially. This is because, in the metal lubrication method of JP '901, higher fatty acid-based lubricants (zinc stearate in JP '901) are adhered to the inner surface of the die merely in a dotted manner, and additionally, the lubricants are peeled off when the metal powder is filled in the die, thereby not forming a uniform lubricant film which is necessary for generating a metal soap film.

In JP '901, neither a metal soap film nor the lowering of the ejection pressure are described.

Therefore, the rejection of Claims 1, 7, 19, 22, 26, 29, 37 and 38 under 35 U.S.C. § 102(b) as anticipated by JP 1997-272901 (JP '901) and the rejection of Claim 20 under 35 U.S.C. § 103(a) over JP '901 are believed to be unsustainable as the present invention is neither anticipated nor obvious and withdrawal of these rejections is respectfully requested.

In addition, the rejection of Claims 14, 16 and 17 under 35 U.S.C. § 103(a) over JP '901 in view of Kondo '760 is respectfully traversed.

US '760 fails to disclose or suggest the use of Ti or Al. Thus, it is not proper to combine US '760 with JP '901. Even if combined, there would be no expectation of success in making a green compact from Ti or Al.

Therefore, the rejection of Claims 14, 16 and 17 under 35 U.S.C. § 103(a) over JP '901 in view of Kondo '760 is believed to be unsustainable as the present invention is neither anticipated nor obvious and withdrawal of this rejection is respectfully requested.

In addition, the rejection of Claims 3, 6, 10, 11, 13, 17 and 36 under 35 U.S.C. § 103(a) over JP '901 in view of Kobayashi is respectfully traversed.

Kobayashi does not cure the defects of JP '901 as it also fails to disclose or suggest that a new metallic soap film being different from the higher fatty acid-based lubricant and comprising the active metallic element is formed on a surface of the green compact.

Therefore, the rejection of Claims 3, 6, 10, 11, 13, 17 and 36 under 35 U.S.C. § 103(a) over JP '901 in view of Kobayashi is believed to be unsustainable as the present invention is neither anticipated nor obvious and withdrawal of this rejection is respectfully requested.

In addition, the rejection of Claims 1, 3, 4, 6, 7, 17, 19, 29, 37 and 38 under 35 U.S.C. § 103(a) over JP 5071206 in view of JP'901 is respectfully traversed.

The combination of JP '206 and JP '901 does not result in the present invention.

In contrast, JP5071206A fail to disclose or suggest a process for compacting a green compact in which a powdery higher fatty acid-based lubricant which is dispersed in a dispersion comprising a surfactant is sprayed onto an inner surface of a die, which is heated; and wherein, in the compacting step, a new metallic soap film being different from the higher fatty acid-based lubricant and comprising the active metallic element is formed on a surface of the green compact.

The spraying of the powdery higher fatty acid-based lubricant which is dispersed in a dispersion comprising a surfactant allows uniform application of the lubricant onto the inner surface of the die. See paragraphs [0067, 0068 and 0069] of the specification. Further as a result of the new uniform metallic soap film formed on the surface of the green compact, the ejection force is remarkably reduced. See paragraphs [0024 and 0025] of the specification. See also **new Claims 37 and 38.**

Notably, the ejection force is reduced by a factor of about 1/10 compared with the case where the conventional powder compacting processes are used. See paragraph [0089] of the specification. At the same time it is possible to increase the compacting pressure and obtain green compact having a high density without a large increase in ejection force. See paragraphs [0089, 0090 and 0091] of the specification.

Further the Examples of the present invention use a die wall lubricant according to the present invention. See paragraphs [0102, 0103, and 0106] of the specification. In contrast, the Comparative Examples use a commercially available dry fluorine lubricant. See paragraph [0110] of the specification. As a result, the ejection force is much larger in all Comparative Examples as shown in Table 1 which is reproduced below.

In addition, JP5071206A fail to disclose or suggest a process for compacting a green compact in which the raw material powder is compacted by warm pressurizing to make the green compact.

The Examiner has recognized that JP '206 does not disclose compacting the raw material powder by warm pressurizing.

However, superior properties are achieved when using the warm compacting as shown by the Examples in the specification.

When compacting is done at **room temperature** as in the Comparative examples, the green compact density, the relative density of the green compact, the sintered body density, the relative density of the sintered body become small. In addition, large dimensional changes before and after sintering occur. Please see the **Table 1** below which is reproduced from page 44 of the specification and **Figures 1-4 and 8 and 9 of the specification**. On the other hand, using the **process according to the present invention, excellent green compact density, excellent relative density of the green compact, excellent sintered body density, and excellent relative density of the sintered body are achieved. In addition, the**

dimensional changes before and after sintering are much smaller than in the

Comparative Examples. The superior properties obtained using the process of the present invention are not disclosed or suggested by JP5071206A and JP '901, either alone or in combination.

TABLE 1

Sample No.	Composition (% by mass)	Compaction pressure (MPa)	Ejection Force (MPa)	Green Compact			Metallic Sintered Body			Note	
				Green-compact Density (g/cm ³)	Relative Density (%)	Outside Dia. after Ejection (mm)	Sintered- body Density (g/cm ³)	Relative Density (%)	Dimension Change before and after Sintering (%)		
Ex.	1-1	Pure Ti	588	3.5	4.025	89.2	23.059	4.325	95.9	-2.60	
	1-2		784	1.9	4.193	93.0	23.061	4.384	97.2	-1.59	
	1-3		980	2.4	4.292	95.2	23.065	4.451	98.7	1.37	
	1-4		1176	2.5	4.364	96.8	23.070	4.496	99.7	-1.11	
	1-5		1372	2.6	4.391	97.4	23.075	4.501	99.8	-0.87	
	1-6		1568	2.2	4.422	98.0	23.079	4.505	99.9	-0.60	
	2-1	Ti-	784	0.9	3.991	91.1	23.065	4.403	99.3	-3.26	Mixture Powder of Pure Ti Powder and Alloy Powder
	2-2	6Al-	1176	0.5	4.201	95.9	23.071	4.407	99.4	-1.61	
	2-3	4V	1568	0.5	4.285	97.8	23.081	4.412	99.5	-0.96	
	3-1	Ti-	784	5.1	3.956	90.2	23.072	4.332	97.4	-3.04	Mixture Powder of said Mixture Powder and Hard- particle Powder TiB ₂ : 6% by mass
	3-2	6Al-	1176	3.6	4.143	94.3	23.078	4.395	98.8	-2.06	
	3-3	4V +6TiB ₂	1568	2.7	4.234	96.5	23.083	4.412	99.2	-1.46	
	4-1	Pure Al	392	0.3	2.613	96.8	22.997	-	-	-	
	4-2		588	0.7	2.656	98.4	22.992	-	-	-	
	4-3		784	0.7	2.672	99.0	22.994	-	-	-	
4-4		980	0.7	2.682	99.4	22.994	-	-	-		
4-5		1176	0.8	2.686	99.5	22.993	-	-	-		
4-6		1372	0.8	2.667	99.8	22.994	-	-	-		
4-7		1568	0.5	2.667	99.8	22.995	-	-	-		
5-1	Al-	588	1.3	2.616	93.4	23.014	-	-	-	Equivalent to JIS A7475	
5-2	6Zn-	980	1.1	2.741	97.9	23.029	-	-	-		
5-3	2Mg- 1.5Cu	1568	1.4	2.794	99.8	23.038	-	-	-		
Comp. Ex.	C1-1	Pure Ti	294	8.0	3.209	71.2	23.068	4.235	93.9	-9.58	Room-temp. Compaction
	C1-2		441	16.3	3.521	78.1	23.075	4.290	95.1	-6.94	
	C1-3		588	24.1	3.728	82.9	23.082	4.300	95.3	-4.95	
	C2-1	Pure Al	392	4.1	2.583	95.7	23.056	-	-	-	Room-temp Compaction
	C2-2		588	5.7	2.615	96.9	23.057	-	-	-	
C2-3		784	6.5	2.640	97.8	23.059	-	-	-		

Only when all claimed conditions (including the warm pressurizing) are satisfied, the ejecting force can be decreased substantially.

For example, as for warm pressurizing, there is the description that “the alcohol-based solvents evaporate instantaneously so that it is possible to form a uniform lubricant film with ease” in [0068] of the specification.

It has been the technical common knowledge that it is impossible to form raw material powders comprising an active metallic element such as Ti and Al by high pressures at industrial level. This is because galling occurs on the inner surface of dies instantaneously or the inner surface of dies is roughened when such high-pressure compacting is carried out. Moreover, it is because the resulting green compacts cannot be ejected from dies. In addition, very expensive dies cannot be used even after one and only high-pressure compacting operation so that a great loss might arise. See paragraph [0011] of the specification.

In addition, the green compacts have a low density because the pressure cannot be increased. For example, when green compacts comprise a Ti powder, the green compacts have a density which is only 80% or less of the true density. See paragraph [0012] of the specification.

Moreover, when Ti powders are formed conventionally by pressuring using an internal lubrication method, a dewaxing step is required additionally before the resulting green compacts are sintered in vacuum. In addition, since the major components of the lubricants used in this instance, such as hydrogen, nitrogen and carbon, are likely solve in Ti, internal lubrication methods are unpreferable. See paragraph [0013] of the specification.

Another concern is the low dimensional accuracy of the green compacts. See paragraph [0014] of the specification.

In case of Al powders there is an additional concern that when Al powders are mixed with lubricants and are formed thereafter, it is impossible to dewax sufficiently because the dewaxing temperature of the lubricants is close to 500 °C approximately, the sintering temperature of the resulting green compacts.

JP5071206A and JP '901 do not recognize the specific requirements necessary for Ti and Al containing metal powders.

However, the process according to the present invention, as set forth in Claim 36, gives excellent green compact density, excellent relative density of the green compact, excellent sintered body density, and excellent relative density of the sintered body. In addition, the dimensional changes before and after sintering are much smaller. See the Examples and Comparative Examples.

Therefore, the rejection of Claims 1, 3, 4, 6, 7, 17, 19, 29, 37 and 38 under 35 U.S.C. § 103(a) over JP 5071206 in view of JP'901 is believed to be unsustainable as the present invention is neither anticipated nor obvious and withdrawal of this rejection is respectfully requested.

In addition, the rejection of Claims 1, 3, 4, 6-9, 11, 12, 14, 15, 17, 19, 21, 23, 25, 29, 37 and 38 under 35 U.S.C. § 103(a) over US 7,083,760 in view of US 6,551,371 is respectfully traversed.

US '760 fails to disclose or suggest the use of Ti or Al. US '371 does not contain a suggestion that Ti and Al may be successfully used in a process as claimed.

Therefore, the rejection of Claims 1, 3, 4, 6-9, 11, 12, 14, 15, 17, 19, 21, 23, 25, 29, 37 and 38 under 35 U.S.C. § 103(a) over US 7,083,760 in view of US 6,551,371 is believed to be unsustainable as the present invention is neither anticipated nor obvious and withdrawal of this rejection is respectfully requested.

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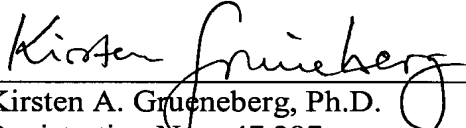
The objections to Claims 14-16 are obviated by the amendments of these claims.

This application presents allowable subject matter, and the Examiner is kindly requested to pass it to issue. Should the Examiner have any questions regarding the claims or otherwise wish to discuss this case, he is kindly invited to contact Applicants' below-signed representative, who would be happy to provide any assistance deemed necessary in speeding this application to allowance.

Respectfully submitted,

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